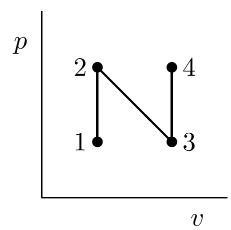
DO NOT WRITE ON THE BLUE TABLES. RETURN THE BLUE TABLES WITH YOUR EXAM. DO NOT STAPLE THE EXAM SHEETS TOGETHER. Put your answers on the same sheet as the question, Use many digits in your computation. You must give the units of your answers. You must write clearly. Encircle the right answer number in multiple choice. To correct, erase the wrong circle as well as you can and encircle the corrected answer number twice. Best possible answer for multiple choice. For questions asking a number, putting the clear correct formula(s) below the question might result in partial credit even if the answer is wrong. *Not following those requirements will result in reduced or no credit.*

1. (5%) The volume of 2kg of neon is changing adiabatically at a rate of 3m^3/s at a time that the pressure is 200kPa. Its temperature is changing at a rate of ___-485.43___ °C/s.

2. (5%) At 227°C ethane has a specific heat at constant pressure equal to ___2.59875___ kJ/kg-K.

3. (5%) An amount of substance undergoes a three-step expansion/compression/expansion process as shown in the figure.



The correct expression for the work performed by the substance in the process is, in terms of the intensive and extensive values of the states 1, 2, 3, and 4 (use subscripts) is: ___$\frac{1}{2}(p_2 + p_3)(V_3 - V_2)$___

4. (5%) Air initially at 200 kPa and 0.5 m^3 expands in a polytropic process with $n = 1.4$ to 1.5 m^3. The final pressure is ___42.96___ kPa and the work ___88.9___ kJ.

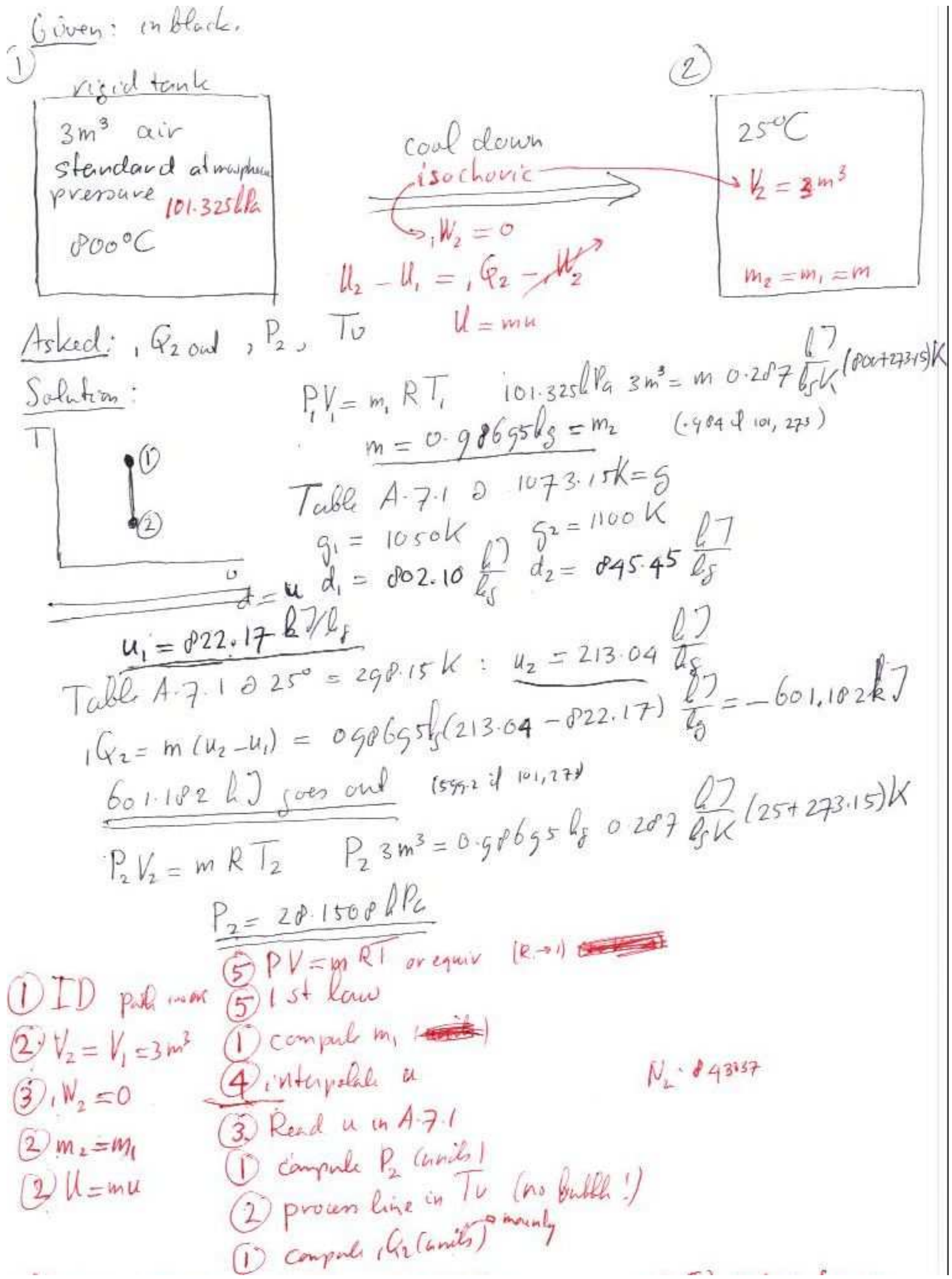
5. (5%) To heat 2kg of engine oil and 3 kg of aluminum from 25°C to 100 °C takes ___487.5___ kJ.

6. (5%) A volume of 2 m^3 of a substance has an enthalpy of 300 kJ and an internal energy of 150 kJ. The pressure is ___75___ kPa.

7. (5%) The temperature of Neon changes from 25°C to 100 °C. The specific internal enthalpy increases by ___77.25___ kJ/kg.

8. A 3 m^3 rigid tank contains air that is initially at standard atmospheric pressure but at 800°C. If you wait long enough, the air will cool down to the ambient temperature of 25°C. What is the heat that has leaked out of the box by then? What is the pressure inside the tank then? Also show the process as a fat curve in the Tv diagram

   You must show the derivations and reasoning completely and correctly for full credit. You must give units for your answers. Most accurate procedure only unless stated otherwise.



9. A steam turbine takes in 5 kg/s of water at 0.8 MPa and 250°C, at a velocity of 300 m/s. The water exits at 100 kPa at negligible velocity. The turbine produces 4.4 MW of power and can be taken to be adiabatic. Find the exit temperature, and if it is defined, the exit quality. Also find the diameter of the entrance pipe.

   You must construct the entrance and exit phases in separate Tv-diagrams, marking all lines and points used to do it with their values. Do not put more info in the diagrams than is needed to construct the phases.

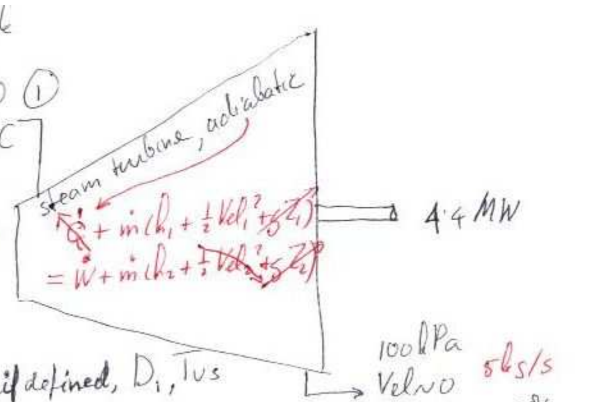
   You must show the derivations and reasoning completely and correctly for full credit. You must give units for your answers. Most accurate procedure only unless stated otherwise.

Given: in black

$5\,kg/s$ H_2O (1)
0.8 MPa 250°C
300 m/s
800 kPa

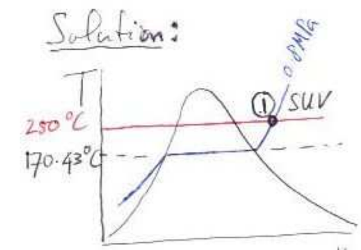
$\dot{m} = \frac{A_1 Vel_1}{v_1}$

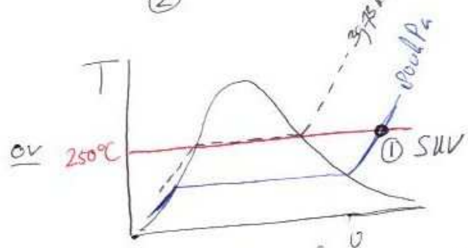
$A_1 = \frac{\pi}{4} D_1^2$



Asked: T_2, x_2 if defined, D_1, Tus

Solution:





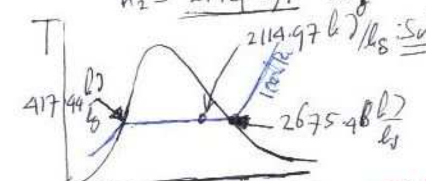
B.1.3 @ 800 kPa, 250°C : $v_1 = \underline{0.29314\ m^3/kg}$ $\underline{h_1 = 2949.97\ kJ/kg}$

$\dot{m} = \frac{A_1 Vel_1}{v_1}$ $\quad 5\,kg/s = \frac{\frac{\pi}{4} D_1^2\ 300\ m/s}{0.29315\ m^3/kg} \Rightarrow D_1 = 0.0789\ m = \underline{7.9\ cm}$ (46 for g=1000)

1st law: $\dot{m}(h_1 + \frac{1}{2}Vel_1^2) = \dot{W} + \dot{m}h_2$ $\quad$ ($\Delta h \sim 45$)

$5\,kg/s\ (2949.97\frac{kJ}{kg} + \frac{1}{2}(300\frac{m}{s})^2 \frac{1\ kJ/kg}{1000\ m^2/s^2}) = 4400\ kW + 5\frac{kg}{s} h_2$

$h_2 = \underline{2114.97\ kJ/kg}$ $\quad$ Saturated so $T_2 = \underline{99.62\ °C}$



$h_2 = h_{f_2} + x_2(h_{g_2} - h_{f_2})$

$2114.97\frac{kJ}{kg} = 417.44\frac{kJ}{kg} + x_2(2675.46 - 417.44)\frac{kJ}{kg}$

$\underline{x_2 = 0.751778}$

2 diagram
2 line 1
2 find sat
2 plot sat
2 line 2
2 identify

5 1st law
2 h_1, v_1 from B.1.3
1 $\dot{m}_2 = \dot{m}_1$
2 $\dot{Q} = 0$
1 compute h_2 (units!)

2 T_2, h_{f_2}, h_{g_2} from B.1.2
5 solve x_2 from $h = h_f + x h_{fg}$
2 $\dot{m} = \frac{A Vel}{v}$
1 $A = \frac{\pi}{4} D^2$